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Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

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Bioelectricity production from agricultural residues: An analysis of Thailand and Kenya

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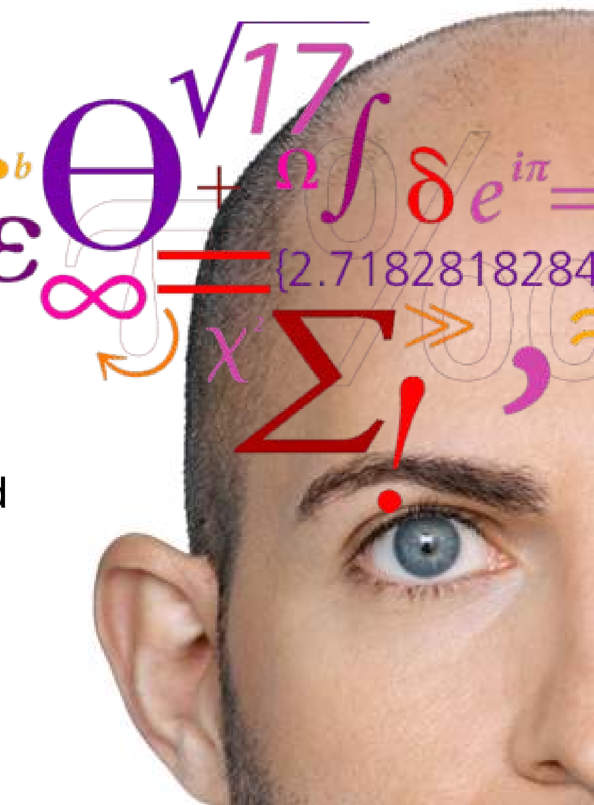

2nd Annual International Conference on Poverty and Sustainable Development

Colombo, Sri Lanka, 15-16th December 2015

Outline

UN City, Copenhagen

- Policy considerations & activities in Bioenergy for Thailand and Kenya
- Resource estimation
- Bioelectricity potential for decentralized applications
- Recommendations
- Conclusions

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Sustainability considerations

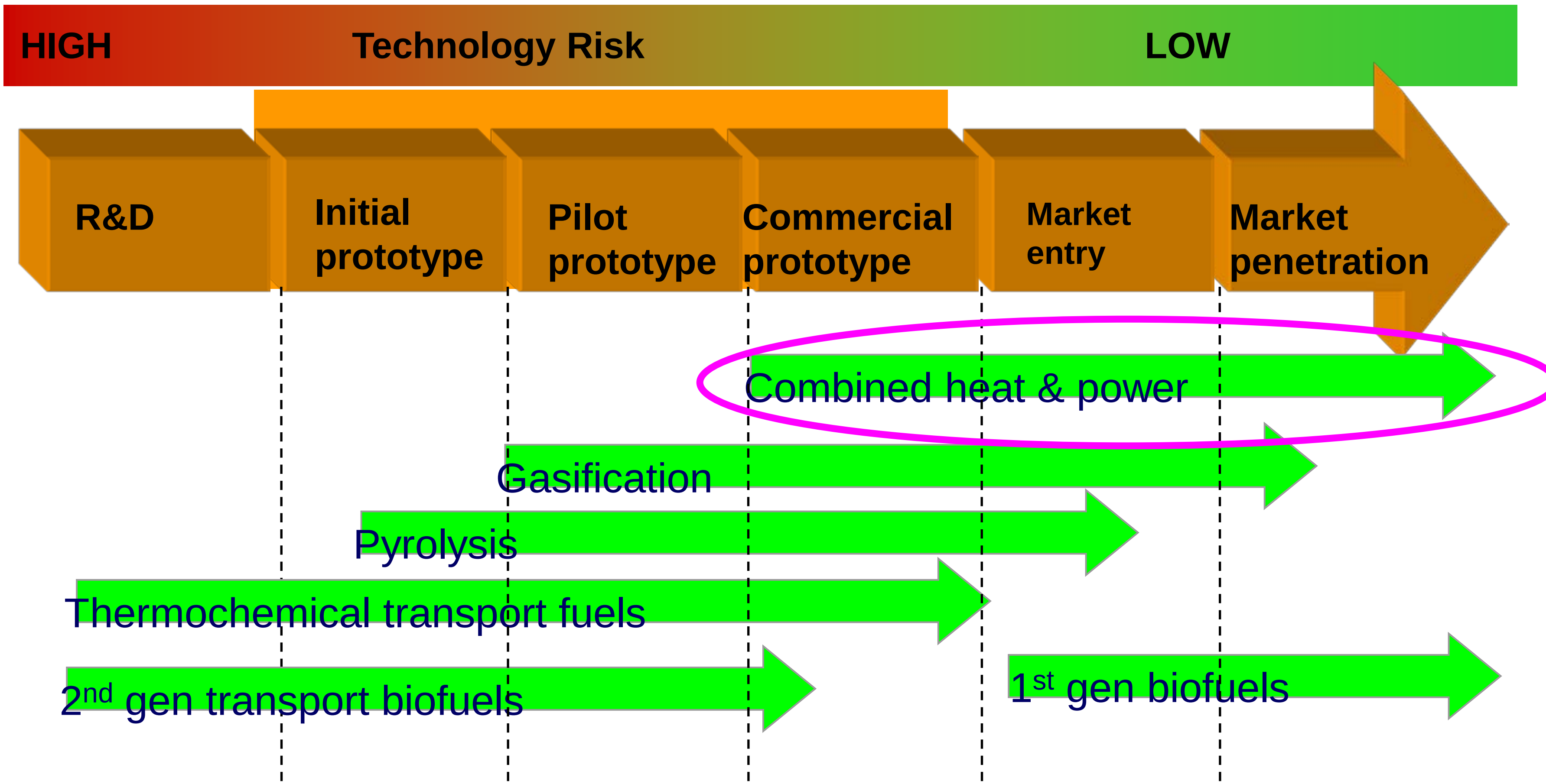
- 1st and 2nd Generation bioenergy, advanced biofuels etc

- Bioenergy sustainability debate
  - Net carbon/energy balances
  - Land use change
  - Food vs. fuel
  - Water footprint
  - Biodiversity
  - Labour issues
  - etc

- Use of residues (including agriculture) often reported as preferred option

(Source: Greenpeace, 2009)

Bioenergy – which technological option?



(Adapted from Ceres Ventures 2007 by IEA Task 39)

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Thailand – Bioenergy Policy considerations

Country	Proposed case studies	Production data	Main specific characteristics
Thailand		**Residue available for energy (Mt, in 2005): 64.80**	Biomass is now playing a greater role as fuel in power generation and as an energy source for bio-liquid fuel production for vehicles. The key factors of the successful promotion of bio-energy programs economy are: 1. Priority of renewable energy in the national energy policy. 2. Authorized government institutions for promoting bioenergy. 3. Implementing renewable energy policy and actions. 4. Continuous and strong support from the government and other financing schemes. 5. Alternative Energy Development Plan (AEDP)
	a) Bioethanol: sugarcane and others	As of March 2010: 19 ethanol plants capacity of 2.93 million liters per day	
	b) Biodiesel – oil palm	As of March 2010: 14 biodiesel production plants total capacity of (B100) 5.9 million liters/ day	
	c) Biogas – rural areas	In 2008, Total production capacity was 300 million m^3 biogas per year The installed capacity of biogas for electricity generation is about 10.6 MW	
	d) Biomass power – bagasse, biogas, residues	Potential of power generation in Thailand from biomass, municipal solid wastes (MSW) and biogas is 3,700 MW by 2011	

(Suani Coelho, GNESD Technical Synthesis, Bioenegy Theme, 2010)

Kenya – Bioenergy Policy considerations

Country	Proposed case studies	Production data	Main specific characteristics
Kenya	a) Biomass cogeneration – bagasse (molasses)	Over the past 10 years, bagasse production in the country has increased by nearly by 30%. In 2008, the sugar factories crushed over 5 million tonnes of sugarcane thereby producing just above 2 million tonnes of bagasse.	Relatively well endowed with biomass resources. In summary there are three main potential sources of modern bioenergy, namely: 1. Use of natural occurring biomass 2. Conversion of biomass waste 3. Commercial grown crops In 1998, close to 25% of the country's electricity was generated from the sugar industry, largely using bagasse, a by-product of the sugar industry. By 2001, electricity generation from sugar estates stood at 40% (half of it from bagasse) of the total electricity supply in country.
	b) Electricity from sugarcane factories	Sugar factories in Kenya could generate nearly 80 MW of electricity.	
	c) Biogas - Landfill gas	Number of installed biogas digesters is about 500 .	
	d) Bioethanol – molasses and sugarcane	It is estimated that about 41 million litres of ethanol could be produced annually based on the existing production of molasses from the sugar production process.	

(Suani Coelho, GNESD Technical Synthesis, Bioenegy Theme, 2010)

Background – Research Framework

Energy from agricultural crops

Bioenergy crops / plantations

- Ecological mapping
  e.g. Brazil, Senegal and Kenya

- Plus sustainability considerations

Agricultural crop residues

- Resource estimation
- This study part of 5 country case examples
- Need to supplement with edaphic-climatic studies
- Bioelectricity potential
- Decentralized systems

References:

1. GNESD. 2013. Biofuels Sustainability Country Reports.

2. Kumar S, Salam PA, Shrestha P, Ackom EK. An Assessment of Thailand's Biofuel Development. *Sustainability*. 2013; 5(4):1577-1597.

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Benefits of mini-grids in remote communities .....

photo credit: Ivan Nygaard,

photo credit: Ivan Nygaard, URC

photo credit: Ivan Nygaard, URC

Making the case for decentralized systems based on local resources – biomass & other RE

- Remoteness
- Price volatilities in crude oil
- Lack of Infrastructure

- Localization of the bioresource
- Cheaper, however storage, logistics etc
- Not so much of a problem

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Thailand – Estimated bioelectricity potential

Source	Food (tonnes/ year)	(RPR)	Residue (dry tonnes/ year)	Residue. 20% (dry tonnes/ year)	Bioelectricity potential TWh (GJ x 0.28 x efficiency x 10E-6)	
					Low	High
Maize	4.45E+06	1.5	5.68E+06	1.14E+06	0.7	2.0
Rice	3.16E+07	1.5	4.03E+07	8.06E+06	5.3	14.0
Sorghum	5.40E+04	2.6	1.20E+05	2.41E+04	0.02	0.05
Sugarcane	6.88E+07	0.3	5.16E+06	1.03E+06	0.6	1.6
Coconut	1.30E+06	0.6	7.01E+05	1.40E+05	0.06	0.2
Coffee	4.90E+04	2.1	8.74E+04	1.75E+04	0.01	0.03
Total				**1.04E+07**	**6.67**	**17.8**

Part of this work focused (with a focus on biofuel) was published recently in:

Kumar S, Salam PA, Shrestha P, Ackom EK. An Assessment of Thailand's Biofuel Development. *Sustainability*. 2013; 5(4):1577-1597.

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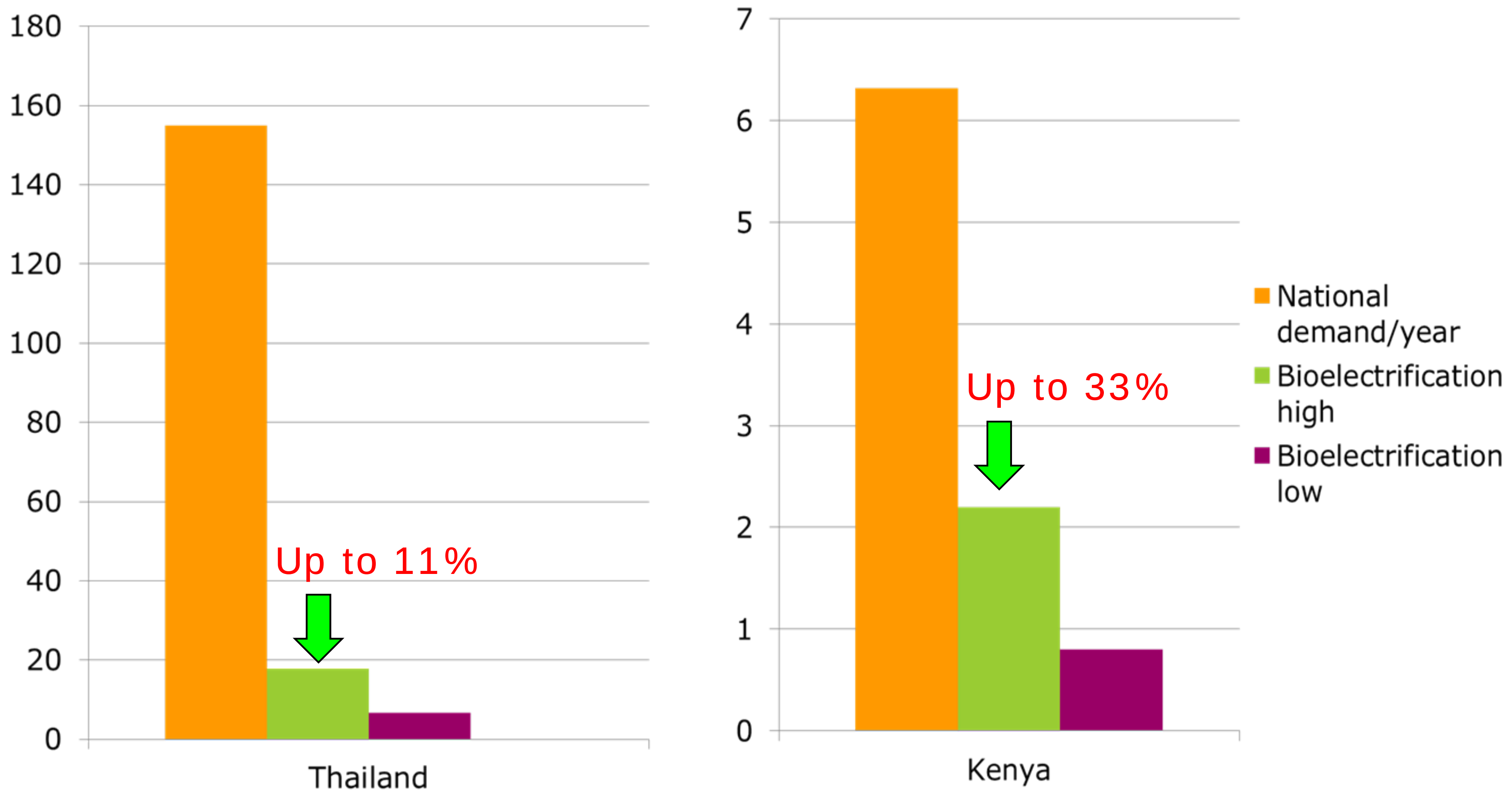
Kenya – Estimated bioelectricity potential

Source	Food (tonnes/ year)	(RPR)	Residue (dry tonnes/ year)	Residue. 20% (dry tonnes/ year)	Bioelectricity potential TWh (GJ x 0.28 x efficiency x 10E-6)	
					Low	High
Maize	3.22E+06	1.5	4.11E+06	8.22E+05	0.6	1.6
Millet	5.39E+04	3.0	1.37E+05	2.75E+05	0.02	0.05
Rice	8.00E+04	1.5	1.02E+05	2.04E+04	0.01	0.04
Sorghum	1.64E+05	2.62	3.65E+05	7.31E+04	0.05	0.14
Wheat	5.12E+05	1.2	5.22E+05	1.04E+05	0.07	0.18
Barley	6.42E+04	1.7	9.28E+04	1.86E+04	0.02	0.04
Sugar cane bagasse	5.71E+06	0.3	4.28E+05	8.56E+04	0.05	0.13
Total				**1.16E+06**	**0.8**	**2.15**

Bioelectrification potential in relation to national electricity demand per year (2012): Thailand & Kenya



Recommendation - bioelectricity potential in the studied countries

- Bioelectricity potential ranges from Thailand (11%) to Kenya (33%) in national electricity consumption amounts.

- Investigations on the edapho-climatic factors regarding the agricultural residues resource assessment that could be taken out.

- Sustainably derived agricultural residues show good potential to make significant contributions to electrification via decentralized systems.

- Benefits are higher in some countries. Admittedly, the potential from agricultural residues varies from country to country.

Conclusions

❖Bioelectrification from agricultural residues presents an opportunity in the food-energy nexus and help address issues pertaining to food (in)security and modern energy provision especially to rural communities in Asia and Africa.

❖ Bioelectrification from residues hold good potential for both Thailand and Kenya, however it seems to have greater potential impact in Kenya compared to Thailand.

❖ Wider uptake in bioelectrification especially in remote communities (possibly in hybrid system) should be studied further

Thank you

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